



PaveXpress

A Simplified Pavement Design Tool

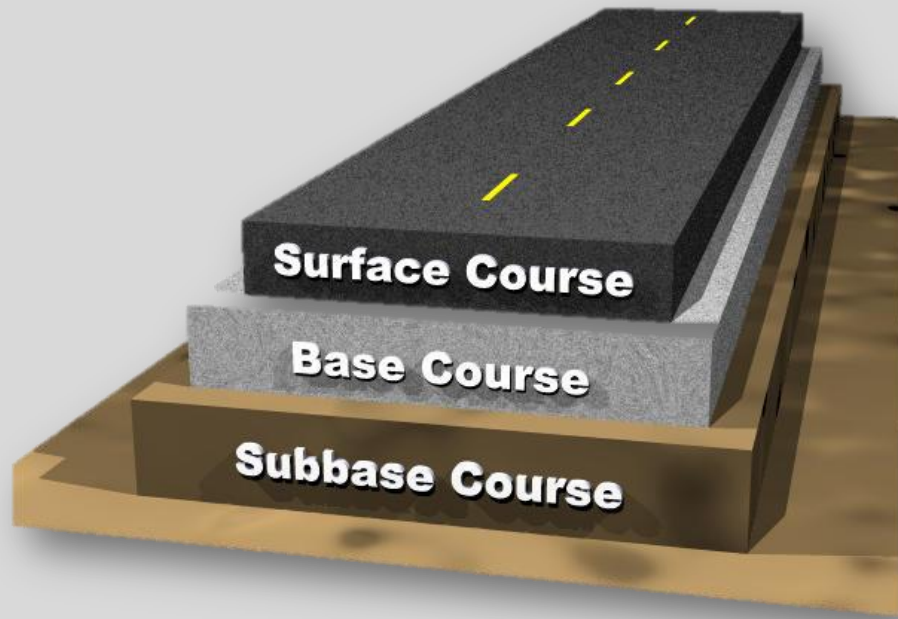
Presented by:
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NJAPA Technical Director

www.PaveXpressDesign.com

Brief Overview

- Why PaveXpress?
- What Is PaveXpress?
- An Introduction
- Overview of the System
- Design Scenarios Using PaveXpress

The screenshot shows the PaveXpress website homepage. At the top left is the PaveXpress logo. To the right is a 'Login' button. Below the logo is a navigation menu with 'Home', 'Getting Started', 'My Projects', and 'About'. The main content area features a large banner image of a highway construction site with several semi-trucks and cars. Below the banner is a 'Welcome to PaveXpress' section with the text 'A simplified pavement design tool for local engineers, consultants, and students.' To the right of the banner are three small thumbnail images with captions: 'Pavement design using AASHTO 93/98', 'Pavement design for engineers and students', and 'Pavement design for project scoping'. Below the banner are three columns: 'Introduction' with a paragraph about the tool's purpose and a 'View Resources' button; 'Resources' with a paragraph about design guides and a 'View Resources' button; and 'Get Started' with a paragraph about launching the tool and a 'Launch' button. At the bottom of the page are copyright information and links for 'Disclaimer', 'Privacy Policy', and 'Terms of Service'.



AASHTO has been developing MEPDG for high volume roads, but a gap has developed for local roads and lower volume roads.

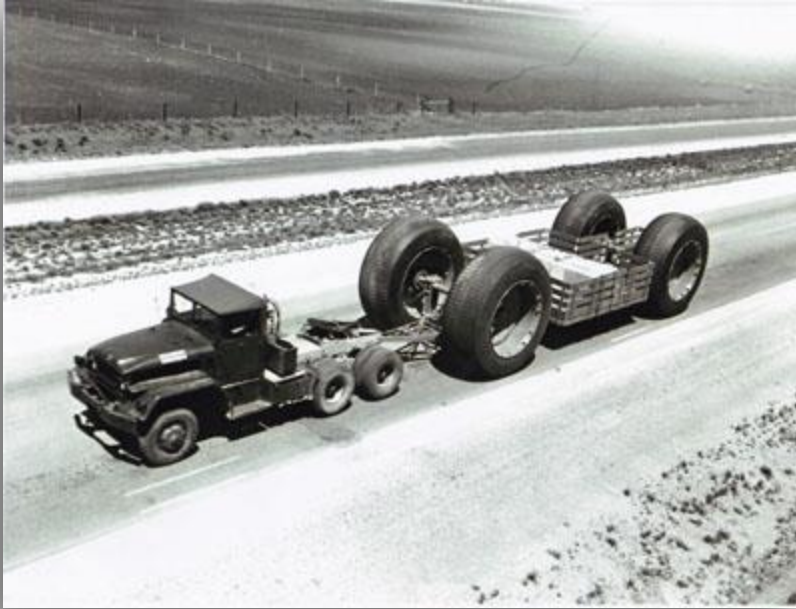
What Is PaveXpress?

A free, online tool to help you create simplified pavement designs using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

- Accessible via the web and mobile devices
- Free – no cost to use
- Based on AASHTO pavement design equations
- User-friendly
- Share, save, and print project designs
- Interactive help and resource links



1993 AASHTO Design Guide Equation – Basic Overview



The equation was derived from empirical information obtained at the AASHTO Road Test.

The solution represents the average amount of traffic that can be sustained by a roadway before deteriorating to some terminal level of serviceability, according to the supplied inputs.

1993 AASHTO Design Guide Equation – Basic Overview

$$\log_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \log_{10}(SN + 1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta PSI}{4.2 - 1.5} \right]}{0.4 + \frac{1094}{(SN + 1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where:

W_{18} = the predicted number of 18-kip equivalent single axle load (ESAL) applications

Z_R = standard normal deviate

S_0 = combined standard error of the traffic prediction and performance prediction

ΔPSI = difference between the initial design serviceability index (p_i) and the design terminal serviceability index (p_t)

M_R = resilient modulus of the subgrade (psi)

1993 AASHTO Design Guide Equation – Basic Overview

The designer inputs data for all of the variables except for the structural number (SN), which is indicative of the total pavement thickness required.

Once the total pavement SN is calculated, the thickness of each layer within the pavement structure is calculated

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \cdots + a_iD_im_i$$

Where:

a_i = i^{th} layer coefficient

D_i = i^{th} layer thickness (inches)

m_i = i^{th} layer drainage coefficient

General Guidance

- The solution represents the pavement thickness for which the *mean value* of traffic which can be carried given the specific inputs. That means there is a 50% chance that the terminal serviceability level could be reached in less time than the period for which the pavement was designed.
- As engineers, we tend to want to be conservative in our work. Understand that as we use values that are more and more conservative, the pavement thickness increases and the overall cost also increases.

General Guidance

- A reliability factor is included to decrease the risk of premature deterioration below acceptable levels of serviceability.
- In order to properly apply the reliability factor, the inputs to the design equation *should be the mean value, without any adjustment designed to make the input “conservative.”*
- The pavement structure most likely to live to its design life will be the one with the most accurate design inputs. Whenever possible, perform materials testing and use actual traffic counts rather than relying on default values or guessing (*too much!*) regarding anticipated traffic levels.

Training - AC New Design

Save Print

- 1 Project Information**
Location, Roadway Classification and Pavement Type
- 2 Design Parameters**
Specific Design Variables
- 3 Traffic & Loading**
Traffic and Loading Data
- 4 Pavement Structure**
Pavement Layer(s) Information
- 5 Pavement Sub-Structure**
Base, Sub-Base and Subgrade
- Design Guidance**

Project Information

Project Name

Project Description

Estimated Completion Year ⓘ

State ⓘ

Roadway Classification ⓘ

Pavement Design

Project Type ⓘ

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Screen 1

1 Project Information

*Location, Roadway Classification and
Pavement Type*

Screen 1

- 1) **Project Name** is an open field, allowing the user to input any desired information.
- 2) **Description** is an open field, allowing the user to input any desired information.
- 3) **Estimated Completion Year** field is used to extrapolate the growth in traffic that may occur while the project is being constructed. Traffic data inputs use data beginning in completion year.
- 4) **State** uses a drop-down box that allows the user to select the state.

1 Project Information

*Location, Roadway Classification and
Pavement Type*

Screen 1

5) Roadway Classification drop-down box allows the user to indicate the functional classification that best describes how the pavement will be used. In PaveXpress, the selection affects default values for design period, reliability, and initial & terminal serviceability index. These default values can be overridden by the user.

Access control is a key factor in the realm of functional classification. For example, all Interstates are “limited access” or “controlled access” roadways. “Access” refers to the ability to access the roadway and not the abutting land. It is difficult to find hard-and-fast rules defining classifications, so some degree of judgment must be exercised here.

Roadway Classifications

Interstate: *All routes that comprise the Dwight D. Eisenhower National System of Interstate and Defense Highways belong to the “Interstate” functional classification category and are considered Principal Arterials.*

Arterials/Highways: *The roads in this classification have directional travel lanes are usually separated by some type of physical barrier, and their access and egress points are limited to on- and off-ramp locations or a very limited number of at-grade intersections. These roadways serve major centers of metropolitan areas, provide a high degree of mobility. They can also provide mobility through rural areas. Unlike their access-controlled counterparts, abutting land uses can be served directly.*

Local: *Local roads are not intended for use in long distance travel, due to their provision of direct access to abutting land. Bus routes generally do not run on Local Roads. They are often designed to discourage through traffic. Collectors serve a critical role in the roadway network by gathering traffic from Local Roads and funneling them to the Arterial network.*

Residential/Collector: *The roads in this classification have the lowest traffic loadings and are basically comprised of automobiles and periodic truck service traffic, such as garbage trucks, etc. The “Collector” name appended to this classification fits more with the “Local” classification above, i.e., “Collector/Local.”*

1 Project Information

*Location, Roadway Classification and
Pavement Type*

6) **Project Type** drop-down box allows the user to indicate the type of pavement being designed:

- New Asphalt, 1993 AASHTO Design Guide
- New Concrete, 1998 Supplement
- AC Overlay on Asphalt, 1993 Guide
- AC Overlay on Concrete or Composite
(No Design Performed)

Screen 1



*This presentation will focus
on New Asphalt designs and
AC Overlay on Asphalt designs*

Main Street

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1 Project Information
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2 Design Parameters
Specific Design Variables

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Pavement Layer(s) Information

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Base, Sub-Base and Subgrade

Calculated Design

Design Parameters

Design Period years

Reliability

Reliability Level (R) $Z_R = -0.674$

Combined Standard Error (S_0)

Serviceability

Initial Serviceability Index (p_i)

Terminal Serviceability Index (p_t)

Change in Serviceability (ΔPSI)

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Screen 2

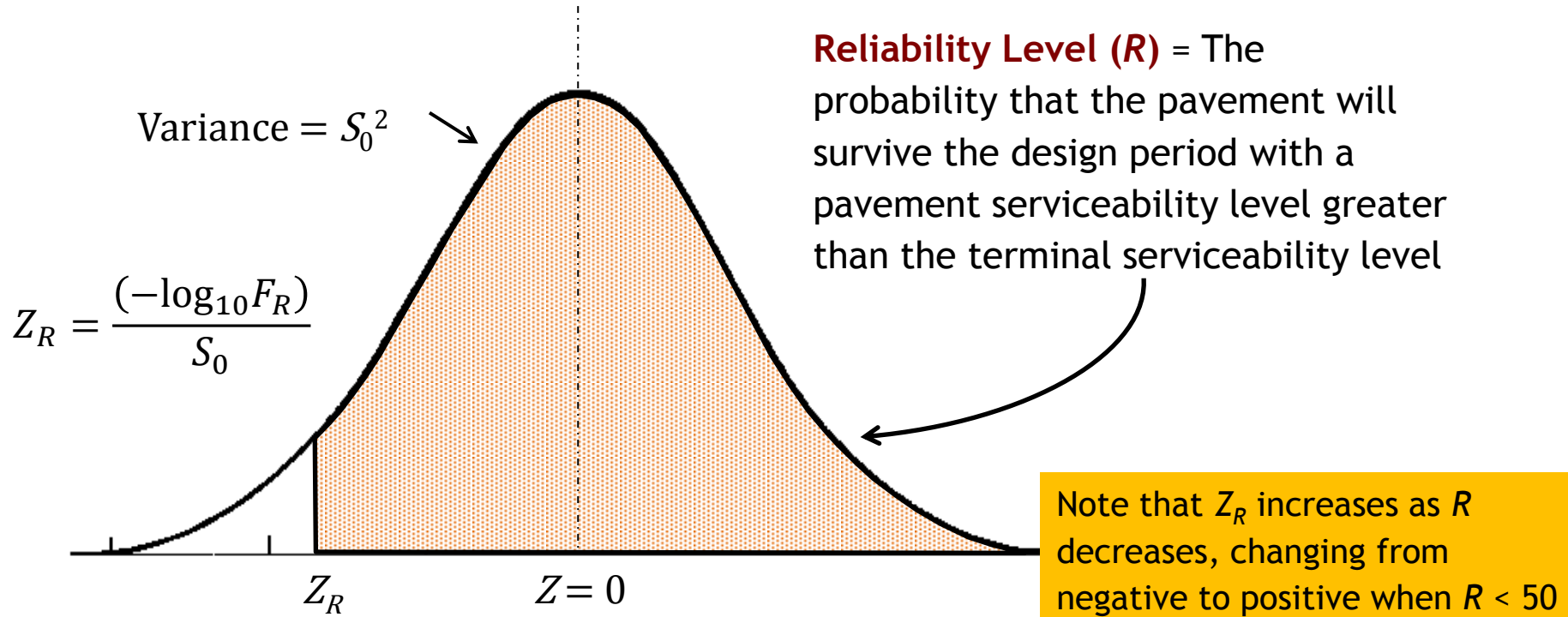
2 Design Parameters

Specific Design Variables

Screen 2

- 1) **Design Period** is the length of time the design is intended to last before the pavement reaches the end of its serviceable life and requires rehabilitation.
- 2) **Reliability Level (R)** is the probability that a pavement section designed using the process will perform satisfactorily over the traffic and environmental conditions for the design period. This is then used to determine the corresponding Z_R .

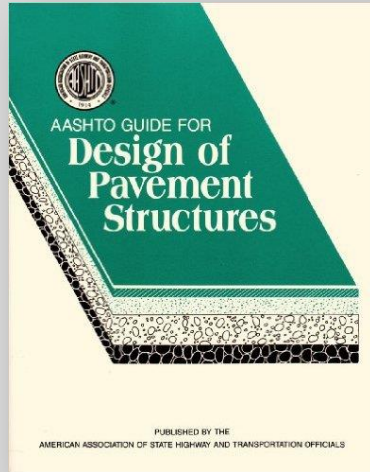
Reliability Level as a Normal Distribution



AASHTO Suggested Reliability Levels For Various Functional Classifications

Reliability Level (R): 50% to 95%, depending on Roadway Classification

The probability that a pavement section designed using the process will perform satisfactorily over the traffic and environmental conditions for the design period. This is then used to look up Z_R , the standard normal deviate which is the standard normal table value corresponding to a desired probability of exceedance level. Suggested levels of reliability for various Functional Classifications (1993 AASHTO Guide, Table 2.2, page II-9):



Functional Classification	Recommended Level of Reliability	
	Urban	Rural
Interstate and Other Freeways	85–99.9	80–99.9
Principal Arterials	80–99	75–95
Collectors	80–95	75–95
Local	50–80	50–80

2 Design Parameters

Specific Design Variables

Screen 2

- 3) **Combined Standard Error (S_0)** A variable that defines the overall design uncertainty involved in the traffic and performance design inputs (the likelihood that actual observed values during the pavement's serviceable life will deviate from these inputs). It is not recommended to change this from 0.5 for flexible pavements.

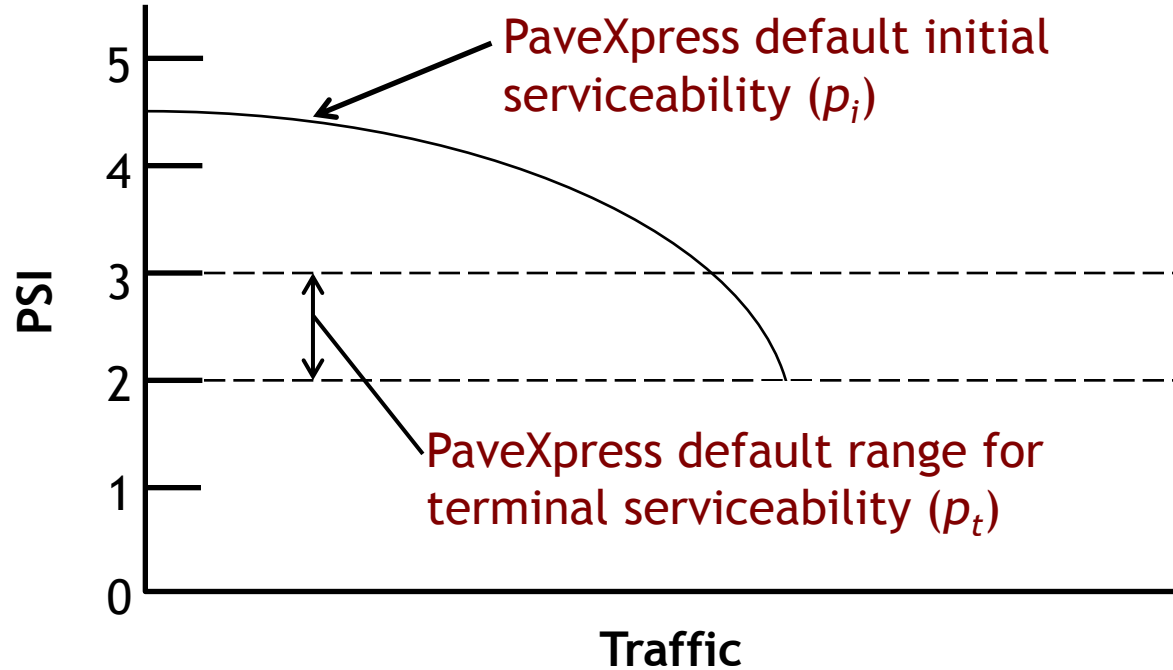
2 Design Parameters

Specific Design Variables

Screen 2

- 4) **Initial Serviceability Index (p_i)** is the Present Serviceability Index (*PSI*) of the pavement immediately after construction.
- 5) **Terminal Serviceability Index (p_t)** is the *PSI* when the pavement is considered to have exhausted its serviceable life.
- 6) **Change in Serviceability (ΔPSI)** is the difference in *PSI* between the time of the pavement's construction and the end of its serviceable life. PaveXpress calculates this number based on the designer's inputs for p_i and p_t ($\Delta PSI = p_i - p_t$).

Present Serviceability Index Concept



Roadway Classification Effect On PaveXpress Default Values

	Interstate	Arterials/ Highway	Local	Residential/ Collector
Design Period	40 years	30 years	20 years	20 years
Reliability Level	95	85	75	50
Combined Standard Error (S_0)	0.5	0.5	0.5	0.5
Initial Serviceability Index (p_i)	4.5	4.5	4.5	4.5
Terminal Serviceability Index (p_t)	3.0	3.0	2.0	2.0
Change in Serviceability (ΔPSI)	1.5	1.5	2.5	2.5

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 **Calculated Design**

Traffic Data

Method of Determining ESALs: **Using AADT** Annual ESALS Design ESALS 

Completion Year Traffic (vehicles) **Calculate from AADT** 

Load Equivalency Factor **Calculate LEF** 

Completion Year ESALS 

Design Period

ESAL Growth Rate % 

Total Design ESALS (W_{18}) 

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Screen 3 AADT

3

Traffic Data







Traffic and Loading Data

Screen 3

1) Method of Determining ESALS by Average Annual Daily Traffic

Calculate Traffic from AADT

Use this page to calculate the completion year traffic level using a historical AADT value. The Directional and Lane adjustment factors come from AASHTO (93). [Learn More](#)

Average Annual Daily Traffic (AADT)	<input type="text" value="1000"/>	<input type="text" value="vehicles"/>	
Lanes Measured (AADT ✕ 1)	<input type="text" value="One-Way"/>		
Directional Lanes (AADT ✕ 1)	<input type="text" value="1"/>		
Year of Traffic Count	<input type="text" value="2015"/>		
Traffic Growth Rate	<input type="text" value="3"/>	<input data-bbox="1586 754 1622 790" type="text" value="%"/>	
Completion Year Traffic	<input type="text" value="387228.5"/>		

3

Traffic Data



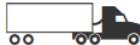
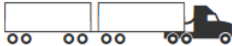

Traffic and Loading Data

Screen 3

1) Method of Determining ESALS by Average Annual Daily Traffic

Calculate Load Equivalency Factor

Use this dialog to establish the Composite Load Equivalency Factor for your project section. The values are used to then determine the ESALS from the vehicle count provided earlier. Default values suggested are from Washington State DOT.

	% of Traffic		Weighted Load Equivalency Factor (LEF)		
	<input type="text" value="0"/>	<input data-bbox="1329 550 1373 576" type="text" value="%"/>	<input type="text" value="X"/>	<input type="text" value="0.0001"/>	<input type="button" value="i"/>
	<input type="text" value="0"/>	<input data-bbox="1329 621 1373 647" type="text" value="%"/>	<input type="text" value="X"/>	<input type="text" value="0.4"/>	<input type="button" value="i"/>
	<input type="text" value="0"/>	<input data-bbox="1329 690 1373 716" type="text" value="%"/>	<input type="text" value="X"/>	<input type="text" value="1"/>	<input type="button" value="i"/>
	<input type="text" value="0"/>	<input data-bbox="1329 758 1373 785" type="text" value="%"/>	<input type="text" value="X"/>	<input type="text" value="1.75"/>	<input type="button" value="i"/>
	<input type="text" value="0"/>	<input data-bbox="1329 827 1373 853" type="text" value="%"/>	<input type="text" value="X"/>	<input type="text" value="0"/>	<input type="button" value="i"/>
Total	<input type="text" value="0"/>	<input data-bbox="1329 893 1373 919" type="text" value="%"/>			
Load Equivalency Factor				<input type="text" value="0"/>	

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 **Calculated Design**

Traffic Data

Method of Determining ESALs:

Using AADT

Annual ESALs

Design ESALs

Completion Year ESALs

0



Design Period

20 Years

ESAL Growth Rate

0

%



Total Design ESALs (W_{18})

0



3

Traffic Data

Traffic and Loading Data

Screen 3

1) Method of Determining ESALS by Average Annual ESALS

Traffic Data

Method of Determining ESALS:

Using AADT

Annual ESALS

Design ESALS

Completion Year ESALS

21,000



Design Period

20 Years

ESAL Growth Rate

4

%



Total Design ESALS (W_{18})

978,000



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Traffic Data

Method of Determining ESALs:

Using AADT

Annual ESALs

Design ESALs



Total Design ESALs (W₁₈)

0



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Screen 3 Design ESALs

Where Can I Find Traffic Data?

- Many DOTs post their traffic count data online
 - <http://www.state.nj.us/transportation/refdata/roadway/traffic.shtm>
- Contact the Traffic Division of the DOT
- Contact the Traffic Division of the city, if available
- If no official traffic count is available, conduct a short-term count
- Interview local people and businesses

The bottom line is, try to document in some way why you selected the number for input into the design software.

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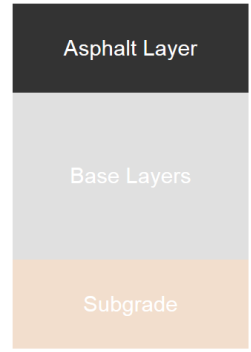
Pavement Structure (Flexible) (Asphalt)

Use Multiple Lifts Yes



Asphalt Layers

Layer	Layer Coef	Drainage	Thickness	Edit?
Surface	0.44	1	1 in.	✎
Binder/Intermediate	0.44	1	2 in.	✎
Base	0.44	1	? in.	✎



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Screen 4

Multiple Asphalt Lifts

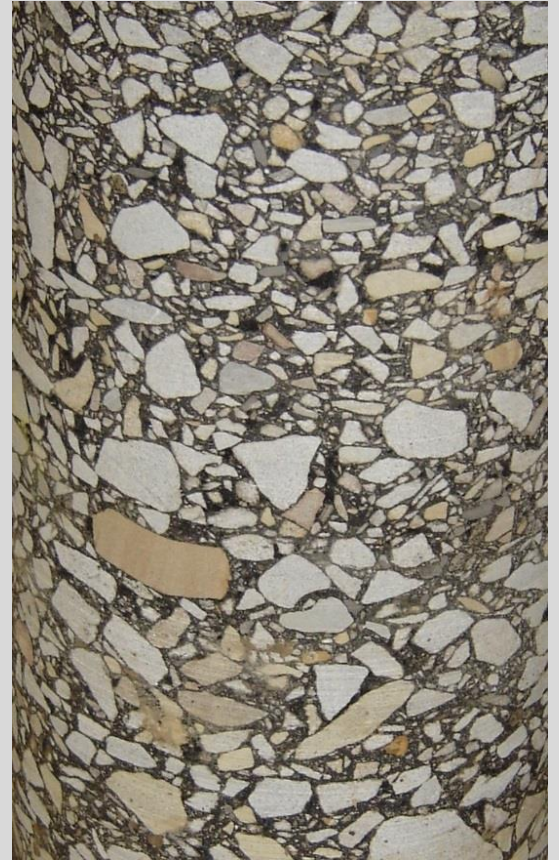
Treating Multiple Asphalt Layers Differently

PaveXpress allows the designer to input for each lift of asphalt a different:

- *layer coefficient*
- *drainage coefficient*
- *thickness*

The designer can either specify individual inputs for the surface, intermediate (binder) course, and base (leaving the program to calculate the base thickness), or input all asphalt info as a single lift and split it into separate lifts afterward.

Optimum Lift Thickness = 4 × NMAAS



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 **Calculated Design**

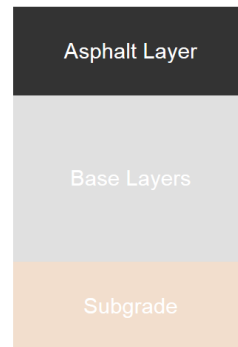
Pavement Structure (Flexible) (Asphalt)

Use Multiple Lifts 

Layer Coefficient (a) 

Drainage Coefficient (m) 

Minimum Thickness in 



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Screen 4 Single Asphalt Lifts

4 Pavement Structure

Pavement Layer(s) Information

Screen 4

- 1) **Layer Coefficient** is a measure of the relative ability of the material to function as a structural component of the pavement. It is used with layer thickness to determine the structural number (*SN*).
- 2) **Drainage Coefficient** represents the relative loss of strength in a layer due to its drainage characteristics and the total time it is exposed to near-saturation moisture conditions. The designer may increase the value from the default of 1 when drainage conditions are favorable, decrease when drainage conditions are poor.
- 3) **Minimum Thickness** is the minimum allowable layer thickness (either per specification, or based on practical construction limitations of the material).

Layer Coefficient Considerations

Average values of layer coefficients for materials used in the AASHO Road Test were as follows:

Asphalt Surface Course	0.44
Crushed Stone Base Course	0.14
Sandy Gravel Subbase	0.11

Keep in mind that these values were empirically derived from a road test with one climate, one soil type, and one asphalt mix type.

The asphalt layer coefficient used for the Road Test was actually a weighted average of values ranging from 0.33 to 0.83.

More recent studies at the NCAT Test Track found that for Alabama, an asphalt layer coefficient of 0.54 better reflected actual performance.

NCAT Report 14-08

RECALIBRATION PROCEDURES FOR THE
STRUCTURAL ASPHALT LAYER COEFFICIENT IN
THE 1993 AASHTO PAVEMENT DESIGN GUIDE

By

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Dr. Mary M. Robbins
Dr. Nam Tran, P.E.
Dr. Carolina Rodezno

November 2014

277 Technology Parkway ■ Auburn, AL 36830

National Center for
Asphalt Technology
NCAT
at AUBURN UNIVERSITY

The cover features three images: a top image showing asphalt being poured from a bucket into a container; a middle image showing several circular asphalt test samples; and a bottom image showing a long, straight asphalt road stretching into the distance with a truck on it.

Drainage Coefficient Considerations

1993 Design Guide Table 2.4 — Recommended m_i Values for Modifying Structural Layer Coefficients of Untreated Base and Subbase Materials in Flexible Pavements

Quality of Drainage	Percentage of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
	< 1%	1–5%	5–25%	> 25%
Excellent	1.40–1.35	1.35–1.30	1.30–1.20	1.20
Good	1.35–1.25	1.25–1.15	1.15–1.00	1.00
Fair	1.25–1.15	1.15–1.05	1.00–0.80	0.80
Poor	1.15–1.05	1.05–0.80	0.80–0.60	0.60
Very Poor	1.05–0.95	0.95–0.75	0.75–0.40	0.40

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Calculated Design

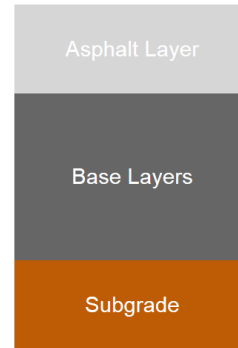
Base Layers

Layer Type	Layer Coef.	Drainage Coef.	Thickness	Resilient Mod	Action?
Click on the Add Layer button below to add a Base Layer.					

Add Layer

Subgrade

Resilient Modulus (M_R) [Calculate MR](#) ⓘ



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Adding an Aggregate Base Layer

The designer can add an aggregate base layer (or any other type of base or subbase layer) here.

The default layer coefficients are reasonable, but can be overridden.

The default resilient modulus (M_R) values came from SHRP2 research, and can also be overridden.

The AASHTO recommended minimum thickness values are:

4" < 500 ESALs

6" > 500 ESALs

Add Base Layer

Thickness (in.)

Required layer thickness (either per specification, or based on practical construction limitations of the material) in inches. The following minimum thicknesses are recommended from AASHTO:

Traffic (000s ESALs)	Base
<500	4 in.
> 500	6 in.

Layer Type:

Layer Coefficient:

Drainage Coefficient:

Resilient Modulus (M_R):

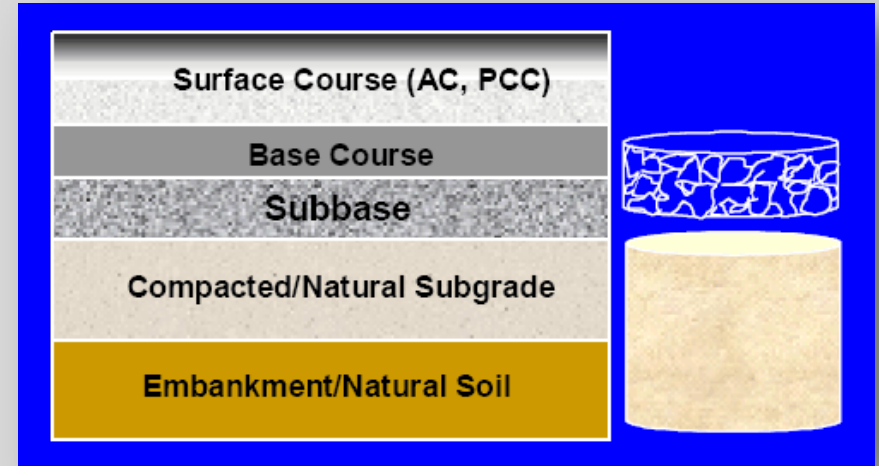
Thickness:

Is Thickness Fixed?

Subgrade Considerations

The most common methods of classifying the subgrade for pavement design are:

- California Bearing Ratio (CBR)
- Resistance Value (R)
- Resilient Modulus (M_R)



California Bearing Ratio (CBR)

The CBR Test can be performed either in the lab(AASHTO T 193, ASTM D 1883) or in the field in situ (ASTM D4429).

The CBR is a simple test that compares the bearing capacity of a material with a standard well-graded crushed stone, which has a reference CBR value of 100%.

Fine-grained soils typically have values less than 20.

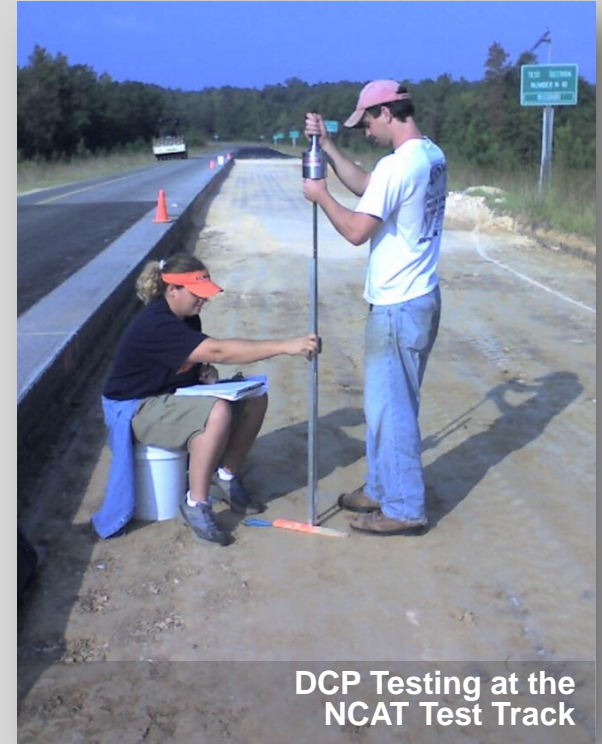


Using the Dynamic Cone Penetrometer to Estimate CBR

The Dynamic Cone Penetrometer (DCP) Test can be performed in the field in situ (ASTM D6951) and used to estimate CBR values.

The U.S. Army Corps of Engineers Waterways Experiment Station developed the following relationship between Dynamic Penetration Index (DPI) and CBR:

$$\log_{10}(\text{CBR}) = 2.46 - 1.12 \log_{10}(\text{DPI})$$



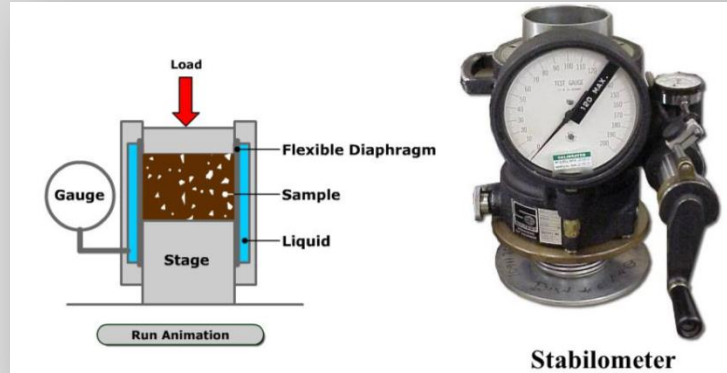
DCP Testing at the NCAT Test Track

Resistance Value (R)

The Resistance Test is performed in the lab (AASHTO T 190, ASTM D 2844).

It tests both treated and untreated laboratory compacted soils or aggregates with a stabilometer and expansion pressure devices. It tests the ability of the material to resist lateral spreading due to an applied vertical load.

A range of values are established from 0 to 100, where 0 is the resistance of water and 100 is the resistance of steel.



Resilient Modulus (M_R)

The Resilient Modulus Test is performed in the lab (AASHTO T 307, ASTM D 2844).

It is a measure of the soil stiffness and tri-axially tests both treated and untreated laboratory compacted soils or aggregates under conditions that simulate the physical conditions and stress states of materials beneath flexible pavements subjected to moving wheel loads.

As a mechanistic test measuring fundamental material properties, it is often thought preferable to the empirical CBR and R -value tests.



Resilient Modulus (M_R)

PaveXpress uses some common empirical expressions used to estimate M_R from CBR and R -values:

$$M_R = 2555 \times \text{CBR}^{0.64}$$

$$M_R = 1000 + (555 \times R)$$

Although these equations may help the designer evaluate materials, it is usually best to determine M_R directly through testing, if possible, rather than from the use of correlation equations.

Subgrade Considerations

The Asphalt Institute publication IS-91 gives the following test values for various subgrade qualities:

Relative Quality	R-Value	California Bearing Ratio	Resilient Modulus (psi)
Good to Excellent	43	17	25,000
Medium	20	8	12,000
Poor	6	3	4,500

Note that different design guides will show different ranges for the various subgrade qualities – use engineering judgment when evaluating subgrade design inputs.

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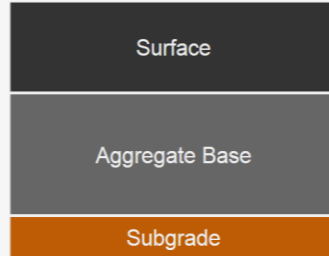
3 Traffic Data
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Calculated Design

Scoped Design



Required minimum design SN: 2.80

Layer Thicknesses (in)

Surface: 4.50

Aggregate Base: 6.00

Total SN: 2.82

[See Calculation Details](#)

Design Notes

Empty text input field for design notes.

Resources



Oklahoma Asphalt Pavement Association

Previous

Screen 6 Calculated Design



Calculated Design

Recommendation:

Perform multiple iterations of the design with different plausible input values to get a sense of the range of pavement structures needed to carry the anticipated loads in various scenarios.

Use engineering judgment to select the optimum pavement structure.

Screen 6



PaveXpress for AC Overlay Design

- AC Overlay Design for Flexible Pavement Rehabilitation Only
- Evaluation Methods for Existing AC Pavement
 - Condition Survey
 - Non-Destructive Deflection Testing
- Includes Questions on Coring and Milling
 - Delamination/Stripping
 - Top-Down or Bottom-Up Cracking
- Adjustment to Existing Pavement Layer Coefficients



Training - AC New Design

Save Print

1 Project Information *Location, Roadway Classification and Pavement Type*

2 Pavement Layers *Pavement Layer(s) Information*

3_a Condition Survey *Visual Assessment*

3_b Layer Coefficients *Structural Parameters Information*

4 Design Parameters *Specific Design Variables*

5 Traffic & Loading *Traffic and Loading Data*

Design Guidance

Project Information

Project Name

Project Description

Estimated Completion Year ⓘ

State ⓘ

Roadway Classification ⓘ

Pavement Design

Project Type ⓘ

Structural Evaluation Method ⓘ

Next

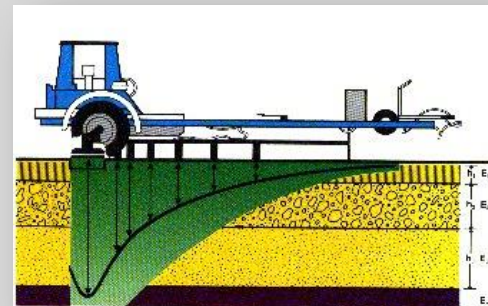
1 Project Information

*Location, Roadway Classification and
Pavement Type*

7) **Structural Evaluation Method** drop-down box allows the user to indicate the type of approach used to evaluate the existing pavement following one of two approaches in the 1993 Guide:

- Condition Survey
- Nondestructive Testing (NDT)

Screen 1



Training - AC New Design

Save Print

1 Project Information
Location, Roadway Classification and Pavement Type

2 Pavement Layers
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3_a Condition Survey
Visual Assessment

3_b Layer Coefficients
Structural Parameters Information

4 Design Parameters
Specific Design Variables

5 Traffic & Loading
Traffic and Loading Data

 Design Guidance

Existing Pavement Layers



Layer Type	Thickness	Action?
Click on 'Add Layer' button below to add the top most pavement layer		

Add Layer

Subgrade

Subgrade Soil Type

Select a Soil Type



Subgrade Modulus (M_R)

psi

Calculate



New AC Overlay

Layer Coeff. (a)



Minimum Thickness



Previous

Next

2 Pavement Layers

Pavement Layer(s) Information

Screen 2

1) **Add Existing Layer:** For the rehabilitation of an pavement, the existing pavement structure must be input. All like materials are grouped into a single layer. For example, all asphalt layers are combined. For each layer, the total thickness must be included. Layer types include:

- Asphalt – Dense Graded
- Asphalt – Open Graded
- Aggregate Base
- Cement Treated Base
- Bituminous Treated Base
- Asphalt Stabilized Base
- Subbase

The screenshot shows a dialog box titled "Add Existing Layer" with a close button (X) in the top right corner. The dialog contains two input fields: "Layer Type" with a dropdown menu showing "Layer Type" and an information icon (i); and "Thickness" with a text input field and a unit dropdown set to "in", also with an information icon (i). At the bottom right, there are "Cancel" and "Add Layer" buttons.

2 Pavement Layers

Pavement Layer(s) Information

Screen 2

2) **Subgrade Soil Type:** Following the input of the pavement structure, subgrade information is needed. The user can use AASHTO classifications for the project. These classifications compare the expected subgrade modulus with the user input value. If the user value is higher or lower than the expected value for the classification, a warning is given.

The screenshot displays the Pavexpress web application interface. The navigation menu includes 'Home', 'Getting Started', 'My Projects', and 'About'. The current page is titled 'Training - AC New Design' and features a sidebar with five main sections: 1. Project Information, 2. Pavement Layers (highlighted), 3a. Condition Survey, 3b. Layer Coefficients, 4. Design Parameters, 5. Traffic & Loading, and Design Guidance. The main content area is divided into three sections: 'Existing Pavement Layers' with a table, 'Subgrade' with input fields, and 'New AC Overlay' with input fields. A dropdown menu for 'Subgrade Soil Type' is open, showing AASHTO classifications from A-1-a to A-7-6. A 'Calculate' button is visible next to the dropdown.

Layer Type	Thickness	Action?
Asphalt - Dense Graded	8 in.	🔗 🗑️
Aggregate Base	6 in.	🔗 🗑️

Subgrade Soil Type:

Subgrade Modulus (M_v):

New AC Overlay Layer Coeff. (a):

Minimum Thickness:

2 Pavement Layers

Pavement Layer(s) Information

Screen 2

3) **Subgrade Modulus:** As with the new design of an asphalt pavement, the overall structure needed to support the anticipated loading is highly dependent on subgrade strength. The user can enter a design modulus based on lab testing or a correlation with CBR or *R*-values

The screenshot shows the Pavexpress software interface for a 'Training - AC New Design' project. The interface includes a navigation menu on the left with sections: 1 Project Information, 2 Pavement Layers (highlighted), 3a Condition Survey, 3b Layer Coefficients, 4 Design Parameters, 5 Traffic & Loading, and Design Guidance. The main content area is divided into 'Existing Pavement Layers' and 'Subgrade' sections. The 'Existing Pavement Layers' section contains a table with columns for Layer Type, Thickness, and Action?. The 'Subgrade' section includes input fields for Subgrade Soil Type (A-1-a), Subgrade Modulus (M_s) (9000 psi), Layer Coeff. (a) (0.44), and Minimum Thickness (1). A 'Calculate' button is present next to the Subgrade Modulus input. The footer of the interface includes copyright information (© Pavia Systems Inc. 2014) and links for Disclaimer, Privacy Policy, and Terms of Service.

Layer Type	Thickness	Action?
Asphalt - Dense Graded	8 in.	↻ ⊗
Aggregate Base	6 in.	↻ ⊗

2 Pavement Layers

Pavement Layer(s) Information

Screen 2

4) **New AC Overlay:** To calculate overlay thickness, two inputs regarding the asphalt material must be provided. First, what layer coefficient to use; a standard value is 0.44, but it can be altered by the designer. The second input is minimum lift thickness for the AC overlay. With most asphalt mixes, this depends on the top stone size. This value should reflect the common asphalt overlay material used.

The screenshot shows the Pavexpress software interface for 'Training - AC New Design'. The interface includes a navigation menu with 'Home', 'Getting Started', 'My Projects', and 'About'. A sidebar on the left contains a list of steps: 1 Project Information, 2 Pavement Layers (highlighted), 3a Condition Survey, 3b Layer Coefficients, 4 Design Parameters, 5 Traffic & Loading, and Design Guidance. The main content area is titled 'Training - AC New Design' and includes a 'Logout' button. Below the title are 'Save' and 'Print' buttons. The 'Existing Pavement Layers' section contains a table with columns 'Layer Type', 'Thickness', and 'Action?'. The table lists 'Asphalt - Dense Graded' with a thickness of 8 in. and 'Aggregate Base' with a thickness of 6 in. Below the table is an 'Add Layer' button. The 'Subgrade' section includes a dropdown for 'Subgrade Soil Type' (set to 'A-1-a'), a text input for 'Subgrade Modulus (M_s)' (set to 9000 psi), and a 'Calculate' button. The 'New AC Overlay' section has a text input for 'Layer Coeff. (a)' (set to 0.44) and a text input for 'Minimum Thickness' (set to 1). At the bottom of the interface are 'Previous' and 'Next' buttons, and a footer with '© Pavia Systems Inc. 2014', 'Disclaimer', 'Privacy Policy', and 'Terms of Service'.

Layer Type	Thickness	Action?
Asphalt - Dense Graded	8 in.	🔗 🗑️
Aggregate Base	6 in.	🔗 🗑️

Existing AC Pavement Evaluation: Two Options

PaveXpress | Home | Getting Started | My Projects | About | Logout

Training - AC New Design

Save | Print

- 1 Project Information
- 2 Pavement Layers
- 3a Condition Survey** (Visual Assessment)
- 3b Layer Coefficients
- 4 Design Parameters
- 5 Traffic & Loading
- Design Guidance

Condition Survey

Alligator Cracking: Low, Medium, High (0% each)

Transverse Cracking: Low, Medium, High (0% each)

Cores: Were cores taken on the roadway? No

Were cores of cracks taken? No

Distressed Pavement: Mill/Remove Distressed Asphalt? Yes

Depth to remove: 0 inches

Previous | Next

Condition Survey

PaveXpress | Home | Getting Started | My Projects | About | Logout

Training - AC Overlay NDT

Save | Print

- 1 Project Information
- 2 Pavement Layers
- 3 Nondestructive Testing (NDT)** (Structural Parameters Information)
- 4 Design Parameters
- 5 Traffic & Loading
- Design Guidance

Backcalculation Results

Design Subgrade Modulus (M_1): 0 | Calculate

SN_{gr} : 0 | Calculate

Cores

Were cores taken on the roadway? No

Were cores of cracks taken? No

Distressed Pavement

Mill/Remove Distressed Asphalt? Yes

Depth to remove: 0 inches

Estimated Structural Coefficient (a): 0

Previous | Next

Nondestructive Testing

Training - AC New Design

Save Print

- 1 Project Information
Location, Roadway Classification and Pavement Type
- 2 Pavement Layers
Pavement Layer(s) Information
- 3_a Condition Survey**
Visual Assessment
- 3_b Layer Coefficients
Structural Parameters Information
- 4 Design Parameters
Specific Design Variables
- 5 Traffic & Loading
Traffic and Loading Data
- Design Guidance

Condition Survey

Alligator Cracking

Low	Medium	High
0 %	0 %	0 %



Transverse Cracking

Low	Medium	High
0 %	0 %	0 %



Cores

Were cores taken on the roadway?

Were cores of cracks taken?

Distressed Pavement

Mill/Remove Distressed Asphalt?

Depth to remove inches

Previous Next

Screen 3_a Condition Survey

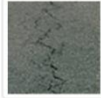

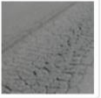


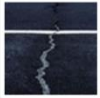


3_a Condition Survey

Visual Assessment

Screen 3_a

1) **Condition Survey:** This approach to assessing the existing pavement's structural capacity relies on a visual condition survey. Two distress types – Alligator Cracking and Transverse Cracking – are evaluated and used in PaveXpress. For each distress type, a percentage by condition type (Low, Medium, or High) is recorded.

Condition Survey

	Low	Medium	High	
Alligator Cracking				
	0 ▾ %	0 ▾ %	0 ▾ %	
Transverse Cracking				
	0 ▾ %	0 ▾ %	0 ▾ %	

While rutting is considered in Chapter 5 of the 1993 Guide, it is highly recommended to mill surfaces that experience rutting.

3_a Condition Survey

Visual Assessment

2) **Cores:** In addition to a visual assessment of the pavement, coring is critical. Coring will aid in confirming the existing pavement structure and retrieving material for lab testing. Just as importantly, cores can be used to determine the direction of cracking, along with the presence of delamination or stripping. The depth of cracks and location of delamination/stripping is used by PaveXpress to guide the user in determining depth of milling needed.

Screen 3_a



Cores

Were cores taken on the roadway?

Yes ▾



Were cores of cracks taken?

Yes ▾



Crack Type

Top-Down Only ▾



Depth of cracks (max)

2 inches



Delamination/Stripping?

Yes ▾



Depth of distress (max)

2 inches



3_a Condition Survey

Visual Assessment

3) **Distressed Pavement:** In many cases, the existing pavement surface is distressed and should be removed prior to placement of a new AC overlay. The designer must define the depth of existing pavement to be removed. This material that is removed will impact the existing structural capacity.

Screen 3_a



Distressed Pavement

Mill/Remove Distressed Asphalt?

Yes ▾



Depth to remove


2

inches



Training - AC New Design


Save Print

- 1 **Project Information**
Location, Roadway Classification and Pavement Type
- 2 **Pavement Layers**
Pavement Layer(s) Information
- 3_a **Condition Survey**
Visual Assessment
- 3_b **Layer Coefficients**
Structural Parameters Information
- 4 **Design Parameters**
Specific Design Variables
- 5 **Traffic & Loading**
Traffic and Loading Data
-  **Design Guidance**

Layer Coefficients

Layer Type	Existing Thickness	AASHTO Recommendation	Layer Coef. (a)	Drainage Coef. (m)	SN
Asphalt - Dense Graded	8"	0.14 to 0.20	<input type="text" value="0"/>	<input type="text" value="1"/>	0.0
Aggregate Base	6"	0.10 to 0.20	<input type="text" value="0"/>	<input type="text" value="1"/>	0.0

SN_{eff} 0.0

 You have elected to remove 2 inches of pavement from the surface. This may impact the layer coefficient you select.

Previous Next

Screen 3_b Layer Coefficients

3_b Layer Coefficients

Structural Parameters Information


Screen 3_b

Layer Coefficients: Based on the condition of the existing pavement's surface, AASHTO provides recommendations for adjusted layer coefficients. If the existing surface and the associated distresses will be removed, then “sound” or common layer coefficients from the remaining layers should be used. If the entire pavement structure is distressed, then a value from the AASHTO Recommendation range should be entered by the user.

Layer Coefficients

Layer Type	Existing Thickness	AASHTO Recommendation	Layer Coef. (a)	Drainage Coef. (m)	SN
Asphalt - Dense Graded	8"	0.14 to 0.20	<input type="text" value="0.44"/>	<input type="text" value="1"/>	3.5
Aggregate Base	6"	0.10 to 0.20	<input type="text" value="0.14"/>	<input type="text" value="1"/>	0.8

SN_{eff} 4.4

 You have elected to remove 2 inches of pavement from the surface. This may impact the layer coefficient you select.

Training - AC Overlay NDT

Save Print

- 1 Project Information
Location, Roadway Classification and Pavement Type
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Pavement Layer(s) Information
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Structural Parameters Information
- 4 Design Parameters
Specific Design Variables
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Traffic and Loading Data
- Design Guidance

Backcalculation Results

Design Subgrade Modulus (M_r) Calculate 

SN_{eff} Calculate 

Cores


Were cores taken on the roadway? 

Were cores of cracks taken? 

Distressed Pavement

Mill/Remove Distressed Asphalt? 

Depth to remove inches 

Estimated Structural Coefficient (a) 

Previous Next

Screen 3 Nondestructive Testing

3 Nondestructive Testing (NDT)

Structural Parameters Information

Screen 3

1) Backcalculation Results – Design Subgrade Modulus:

The subgrade modulus value is very important to the required structural capacity of the pavement. PaveXpress allows for direct entry of a modulus based on deflection testing and backcalculation. If the user has not performed backcalculation, then raw deflection data can be entered (Calculate button). It is suggested the user enter data from the 18", 24", or 36" sensor when using this approach.

Please note, the Design Subgrade Modulus and the Subgrade Modulus on Screen 2 may not be equal.

PaveXpress uses the Design Subgrade Modulus with the NDT method for calculating overlay designs.

The screenshot shows a dialog box titled "Calculate Subgrade Modulus" with a close button (X) in the top right corner. The dialog contains the following input fields and controls:

- Applied Load (P)**: A text input field followed by a unit selector set to "lbs". An information icon (i) is to the right.
- Radial Distance (r)**: A text input field followed by a unit selector set to "in". An information icon (i) is to the right.
- Deflection of radial distance (d_r)**: A text input field followed by a unit selector set to "in". An information icon (i) is to the right.
- C-value**: A text input field containing the value ".33". An information icon (i) is to the right.
- Subgrade Modulus (M_R)**: A text input field followed by a unit selector set to "psi".

At the bottom right of the dialog, there are two buttons: "Cancel" and "Set MR and Close".

3 Nondestructive Testing (NDT)

Structural Parameters Information

Screen 3

- 1) **Backcalculation Results – SN_{eff}** : The effective structural number is used to characterize the condition of the pavement. PaveXpress allows for direct entry of a SN_{eff} based on deflection testing and backcalculation. If the user has not performed backcalculation, then raw deflection data can be entered (Calculate button). Using the total pavement structure and the Design Subgrade Modulus, SN_{eff} is computed.

Calculate Effective Strength using Deflection

Deflection (d_0) in ⓘ

Contact Pressure (p) psi ⓘ

Load Plate Radius (a) in ⓘ

Pavement Thickness (D) 14 in ⓘ

Design Subgrade Modulus (M_R) 7500 psi ⓘ

(E_p) psi ⓘ

(SN_{eff}) ⓘ

Cancel Set SN_{eff} and Close

3 Nondestructive Testing (NDT)


Structural Parameters Information


2) **Cores:** In addition to a visual assessment of the pavement, coring is critical. Coring will aid in confirming the existing pavement structure and retrieving material for lab testing. Just as importantly, the cores can be used to determine the direction of cracking along with the presence of delamination or stripping. The depth of cracks and location of the delamination/stripping is used by PaveXpress to guide the user in determining depth of milling.


Screen 3





Cores


Were cores taken on the roadway? 

Were cores of cracks taken? 

Crack Type 

Depth of cracks (max) 

Delamination/Stripping? 

Depth of distress (max) 

3

Nondestructive Testing (NDT)




Structural Parameters Information

3) Distressed Pavement: In many cases, the existing pavement surface is distressed and should be removed prior to placement of a new AC overlay. The designer must define the depth of existing pavement to be removed. This material that is removed will impact the existing structural capacity.

Unlike the condition survey method, with NDT the designer must assign a layer coefficient for the distressed material being removed. This value should correspond to the distress present following the AASHTO Condition Survey recommendations.

Screen 3

Distressed Pavement

Mill/Remove Distressed Asphalt?	Yes ▾	
Depth to remove	2 inches	
Estimated Structural Coefficient (a)	0.25	

Training - AC New Design

Save Print

- 1 Project Information
Location, Roadway Classification and Pavement Type
- 2 Pavement Layers
Pavement Layer(s) Information
- 3_a Condition Survey
Visual Assessment
- 3_b Layer Coefficients
Structural Parameters Information
- 4 Design Parameters
Specific Design Variables
- 5 Traffic & Loading
Traffic and Loading Data
- Design Guidance

Design Parameters

Design Period years i

Reliability

Reliability Level (R) $Z_R = -1.037$ i

Combined Standard Error (S_0) i

Serviceability

Initial Serviceability Index (p_i) i

Terminal Serviceability Index (p_t) i

Change in Serviceability (ΔPSI) i

Previous Next

Screens 4 & 5

The information on these screens is the same as for new pavement designs.

One area for consideration, however, is the Design Period. For most AC overlays, a design life of 10 to 20 years is common.

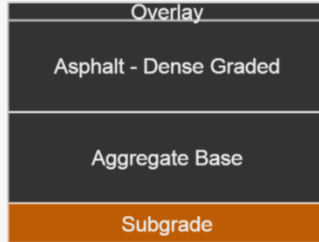
The period is generally in line with the expected life of the asphalt surface mix.

Training - AC New Design

Save Print

- 1 Project Information**
Location, Roadway Classification and Pavement Type
- 2 Pavement Layers**
Pavement Layer(s) Information
- 3_a Condition Survey**
Visual Assessment
- 3_b Layer Coefficients**
Structural Parameters Information
- 4 Design Parameters**
Specific Design Variables
- 5 Traffic & Loading**
Traffic and Loading Data
- Design Guidance**

Scoped Design



Layer Thicknesses (in)

Overlay: 1.2
Asphalt - Dense Graded: 6
Aggregate Base: 6
[See Calculation Details](#)

Design Notes

You have removed 2 inches from the surface of the pavement prior to the overlay in this design.

Resources

Previous

Screen 6 Calculated Design



Overlay: Once the existing pavement information is input, PaveXpress uses the AASHTO equations to calculate the existing or effective structural number (SN) of the pavement. From the design and loading information, the required SN to support the loadings over the design life is calculated. The difference in the required SN and the existing SN is converted to an overlay thickness. If this thickness is less than minimum thickness input on Screen 2 or the required SN is less than the existing SN , then PaveXpress will report the minimum overlay thickness value.

Understanding the Effect of PaveXpress Default Values on Calculated Thickness

- 1) **Design Period** – if the designer uses the total design ESAL count as the traffic input, changing the design period on Screen 2 has no direct effect on calculated thickness. However, if the designer uses the program to calculate ESALs instead of inputting them directly, this design period is used in the calculation.
- 2) **Reliability Level (R)** – as the selected Reliability Level increases, the calculated pavement thickness increases.
- 3) **Initial Serviceability Index (p_i)** – if an occasion arises that p_i is lower than the default of 4.5 (the program only allows an input down to 4.0), the calculated pavement thickness would increase because the Change in Serviceability would, by definition, decrease.
- 4) **Terminal Serviceability Index (p_t)** – if choosing a different p_t than the default value, the calculated pavement thickness would increase as the Change in Serviceability decreases.

Understanding the Effect of PaveXpress Default Values on Calculated Thickness

- 5) **Change in Serviceability Index (Δ PSI)** – as the allowable change in serviceability between initial construction and terminal serviceability decreases, the calculated pavement thickness increases.
- 6) **Total Design ESALs** – as the amount of expected traffic increases, the calculated pavement thickness increases.
- 7) **Layer Coefficient** – as any layer coefficient increases, the calculated pavement thickness decreases.
- 8) **Drainage Coefficient** – as any drainage coefficient decreases, the calculated pavement thickness increases. Because this factor has such a negative influence on calculated thickness and likely decrease in pavement longevity, the subgrade should be modified in some manner to improve drainability instead of increasing asphalt thickness in hopes of bridging the problem.

Rigid Pavements

PaveXpress can also be used to design rigid pavements in accordance with the AASHTO Design Guide 1998 Supplement for Rigid Pavements.

The steps are similar, but geared toward the values and inputs important to concrete pavements.



PaveXpress

Home Getting Started - My Projects About -

PCCP

1 Project Information
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2 Design Parameters
Specific Design Variables

3 Traffic & Loading
Traffic and Loading Data

4 Pavement Structure
Pavement Layer Information

5 Pavement Sub-Structure
Base, Sub-Base and Subgrade

Design Guidance

Design Parameters

Design Period: 30 years

Reliability: 85% $Z_R = -1.037$

Combined Standard Error (C_s): 0.4

Serviceability: Initial Serviceability Index (I_s): 4.5
Terminal Serviceability Index (I_t): 3
Change in Serviceability (ΔPSI): 1.5

Climate: Nearest City: Providence
Mean Annual Wind Speed: 10.6 mph
Mean Annual Temperature: 50.3 °F
Mean Annual Precipitation: 45.3 in

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PaveXpress

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PCCP

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4 Pavement Structure
Pavement Layer Information

5 Pavement Sub-Structure
Base, Sub-Base and Subgrade

Design Guidance

Pavement Structure (PCC)

Modulus of Rupture (R_s): 800 psi

Elastic Modulus (E_s): 4,000,001 psi

Pavement's Rolloff (R_f): 0.3

Pavement Joint and Edges (PCC)

Joint Spacing (J_s): 170 in

Load Transfer Coefficient (L_t): 3

Edge Support (E_s): 1.01

Diagram: PCC Layer, Base Layers, Subgrade

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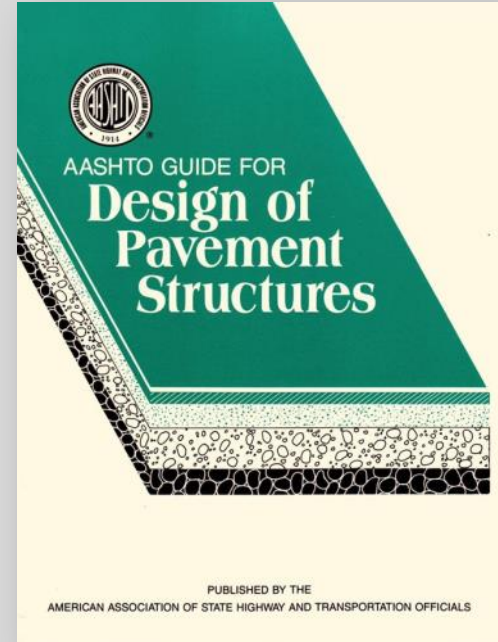
1998 AASHTO Design Guide Equation – Basic Overview

$$\log_{10}(W_{18}) = Z_R \times S_0 + 7.35 \times \log_{10}(D + 1) - 0.06 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.5 - 1.5}\right)}{1 + \frac{1.624 \times 10^7}{(D + 1)^{8.46}}} + (4.22 - 0.32p_t) \times \log_{10}\left[\frac{(S'_c)(C_d)(D^{0.75} - 1.132)}{215.63(J)\left(D^{0.75} - \frac{18.42}{(E_c/k)^{0.25}}\right)}\right]$$

Where:

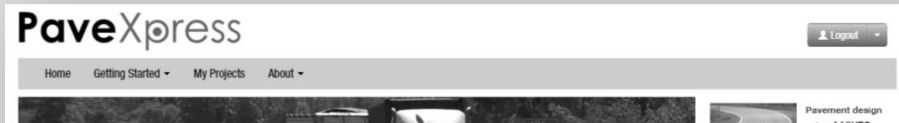
- W_{18} = the predicted number of 18-kip equivalent single axle load (ESAL) applications
- Z_R = standard normal deviate
- S_0 = combined standard error of the traffic prediction and performance prediction
- D = slab depth (inches)
- ΔPSI = difference between the initial design serviceability index (p_i) and the design terminal serviceability index (p_t)
- S'_c = modulus of rupture of PCC (flexural strength)
- C_d = drainage coefficient
- J = load transfer coefficient
- E_c = elastic modulus of PCC
- k = modulus of subgrade reaction

QUESTIONS?



PaveXpress

A Simplified Pavement Design Tool



www.PaveXpressDesign.com

